# Ecological Indicators for Floodplain Forests of the Wisconsin River

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“Ecological investigations...have demonstrated [riparian corridors] to be key landscape features...[that] maintain biodiversity by providing an unusually diverse array of habitats and ecological services.”

- Naiman et al. 1993

# Overall Project Objectives

- Identify landscape metrics that are most useful for monitoring population, community, and ecosystem processes in large-river floodplains.

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- Identify the constraints on extrapolating relationships between landscape metrics and ecological processes in large-river floodplains.

# Motivation

- Development of indicators that use available data and correlate well with ecological function is a widely recognized research need.
- Many existing data sources can be used to quantify patterns.
- Many important environmental changes occur at spatial scale of landscapes.

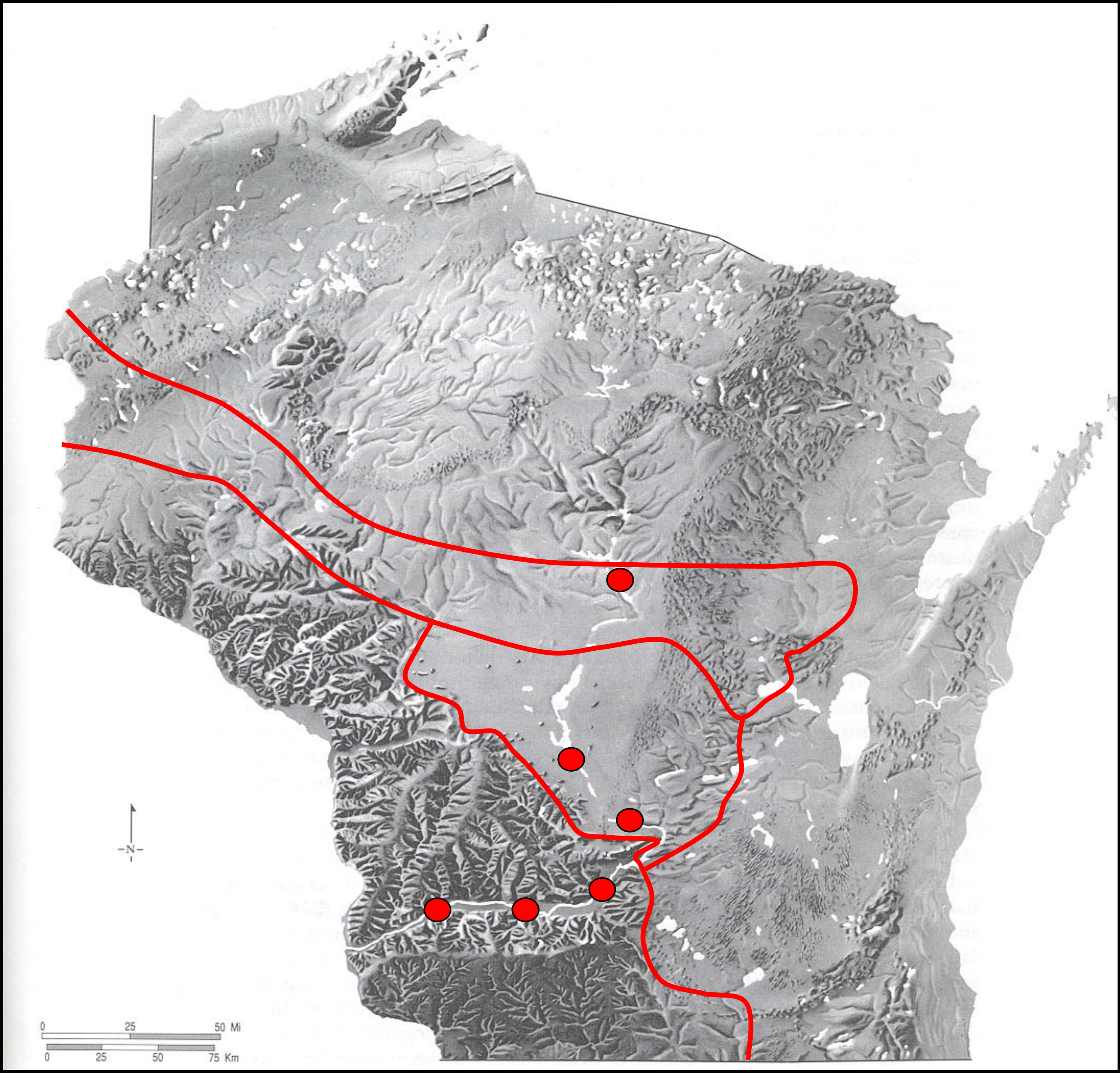
Habitat Fragmentation

Land-use Change

# Hydrologic Alteration

# Approach

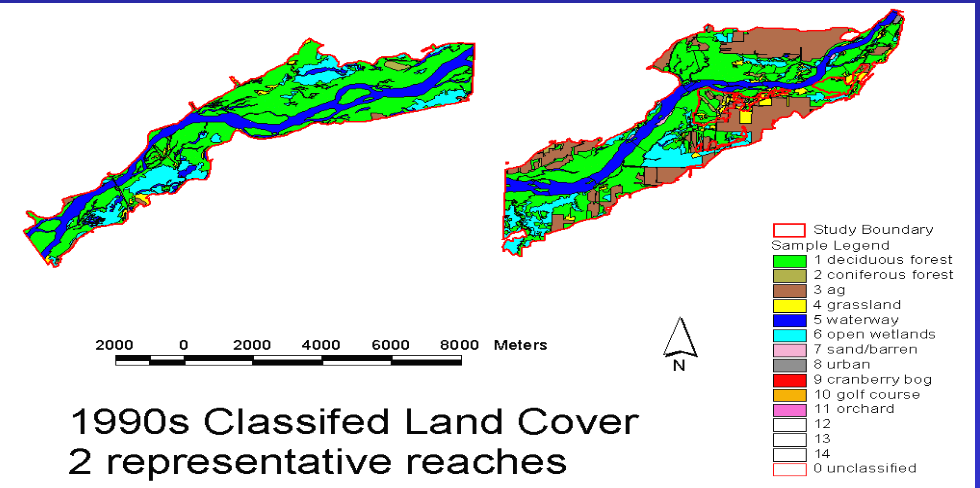
- 1999-2001
  - Conduct intensive yet broad-scale field studies in six study reaches.
  - Relate landscape metrics to ecological response variables.
- 2002
  - Test predicted relationships in three new reaches.
  - Assess constraints on extrapolation through statistical analyses and modeling.


N
0
25
50 Mi
0
25
50
75 Km

# Study Reach Characteristics

| Reach | Length (km) | Area (km$^2$) | % Forest | Dist. up (km) |
|---|---|---|---|---|
| Stevens Point | 12 | 17 | 47 | 329 |
| Necedah | 20 | 33 | 53 | 223 |
| Wisc. Dells | 21 | 106 | 42 | 178 |
| Sauk City | 18 | 53 | 44 | 118 |
| Spring Green | 18 | 32 | 49 | 88 |
| Blue River | 16 | 27 | 57 | 40 |

Blue River




Wisconsin Dells

# Dominant Trees

- River Birch (*Betula niger*)
- Cottonwood (*Populus deltoides*)
- Silver Maple (*Acer saccharinum*)

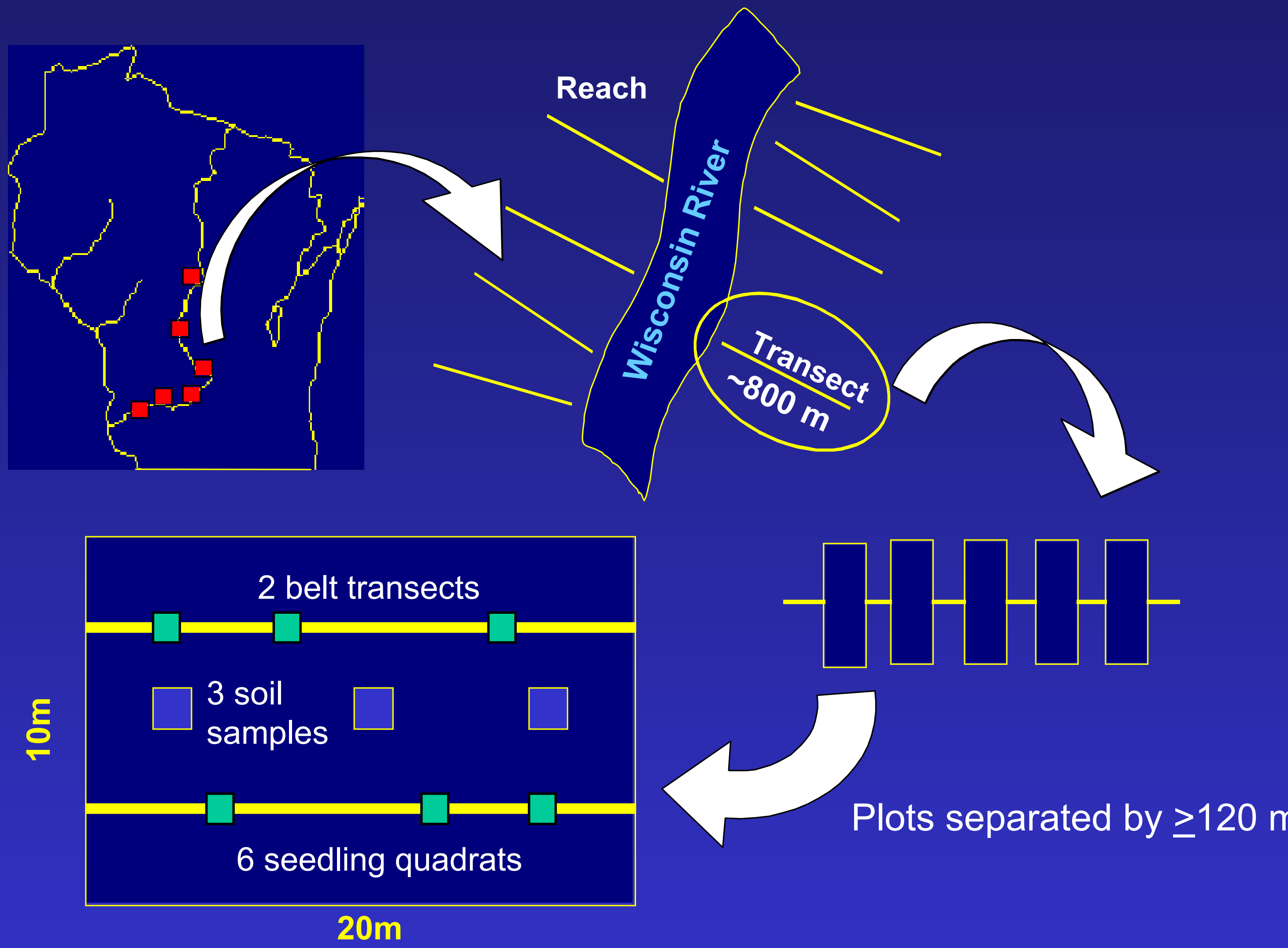
↓

- Green Ash (*Fraxinus pennsylvanica*)
- American Elm (*Ulnus americana*)
- Swamp White Oak (*Quercus bicolor*)

↓

- Basswood (*Tilia americana*)
- Northern Hackberry (*Celtis occidentalis*)
- Bitternut Hickory (*Carya cordiformis*)
- Oak spp. (*Quercus* spp.)

# Field Sampling



# Data Analyses

- Community structure
  - Ordination (CA and CCA)
- Occurrence of species
  - Logistic regression
- Abundance of species (when present), functional groups
  - Multiple regression

# Key Tree Species

Floodplain Forest Birds

# Questions – Tree Species

- How do geography, flooding, land cover and soils influence riparian forests in the Wisconsin River floodplain?

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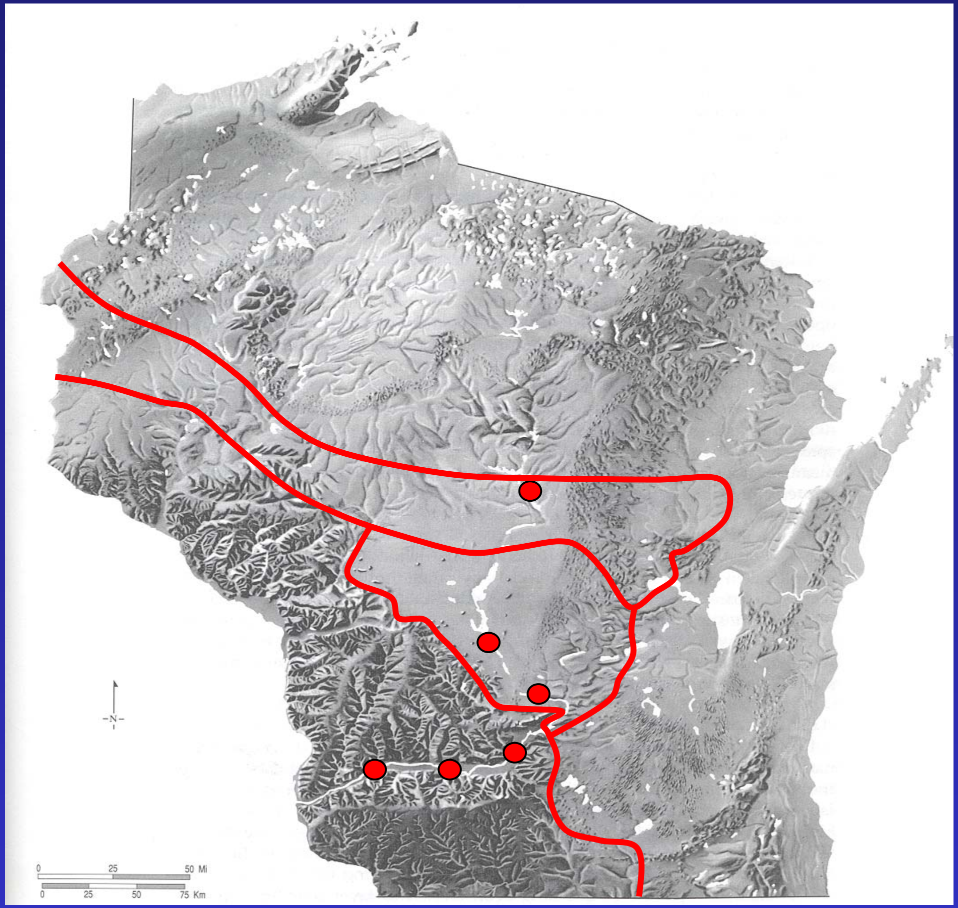
- How do geography, flooding, land cover and soils influence riparian forests in the Wisconsin River floodplain?

- Can “landscape indicators” explain variation in the floodplain forest, or are local field measurements (soils) needed?

# Geographic Measures




- River distance from the Mississippi River
- Northing
- Easting
- Geographic Province

# Measures of Flooding Potential

- lateral distance to Wisconsin River
- relative elevation of plot
- inside/outside levee

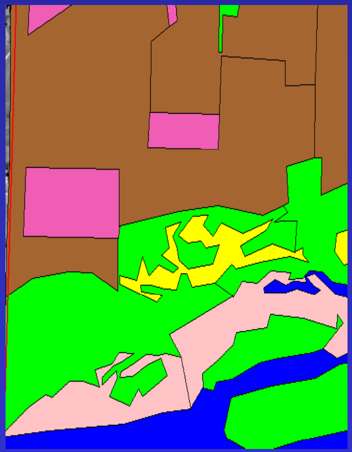
# Forest Patch Measures

- patch area
- distance to forest edge

# Land-cover history obtained from aerial photography
(Freeman et al. In Press)

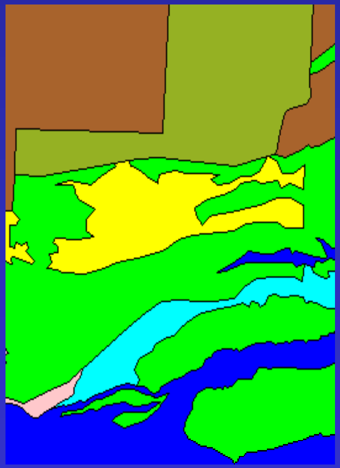
**1937**


**INTERPRETATION**



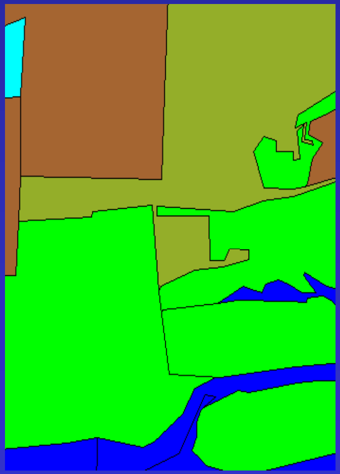
**1968**

**INTERPRETATION**



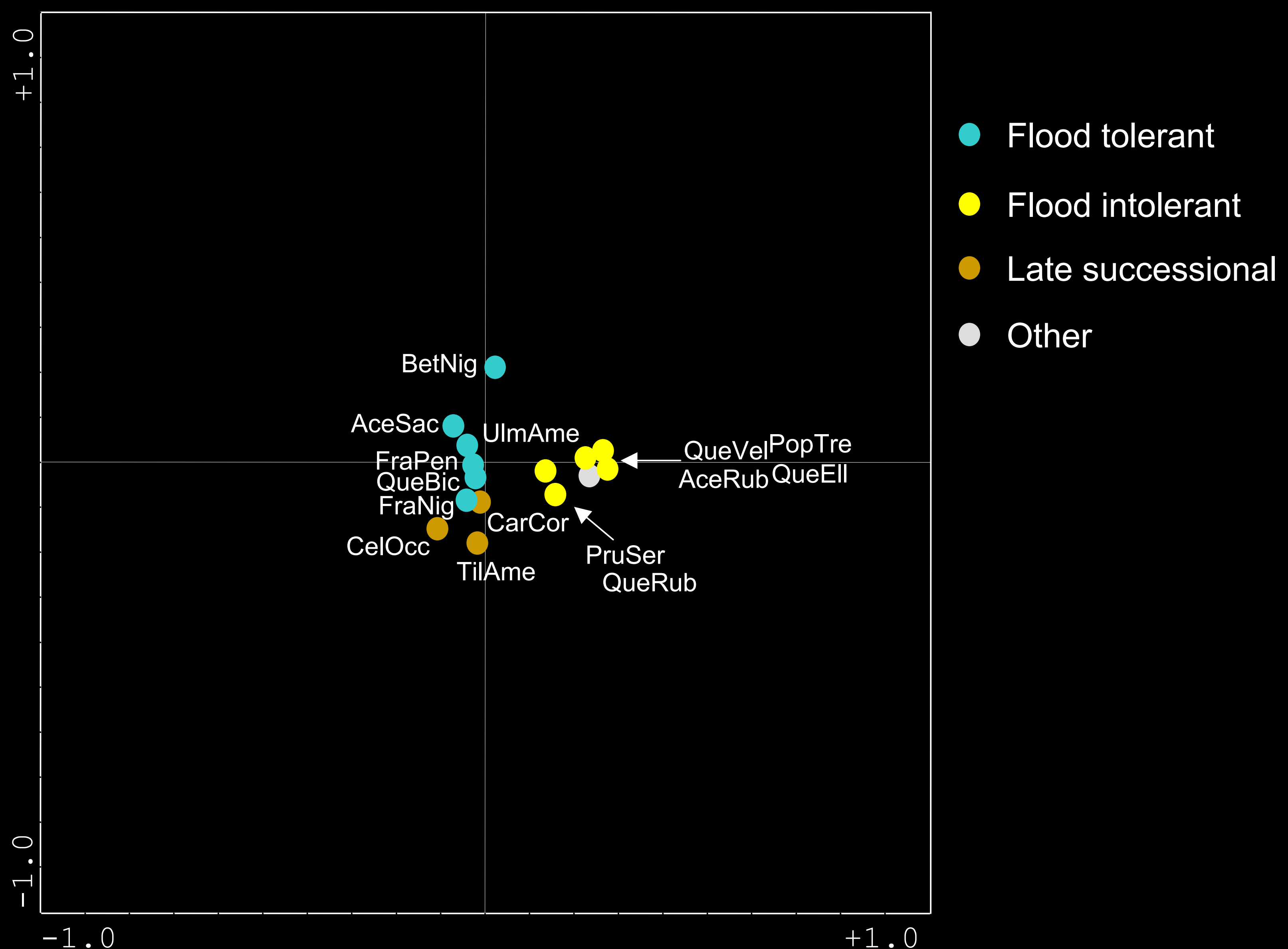
**1992**

**INTERPRETATION**



# Methods

- Vegetation sampled in 405 plots (10 m x 20 m)
- All trees > 2.5 cm dbh identified to species and dbh recorded
- Composite soil sample obtained on each plot for %organic matter, texture, cations, pH



+1.0
-1.0
-1.0
+1.0
BetNig
AceSac
UlmAme
FraPen
QueBic
FraNig
CelOcc
TilAme
CarCor
QueVel
PopTre
AceRub
QueEll
PruSer
QueRub
Flood tolerant
Flood intolerant
Late successional
Other

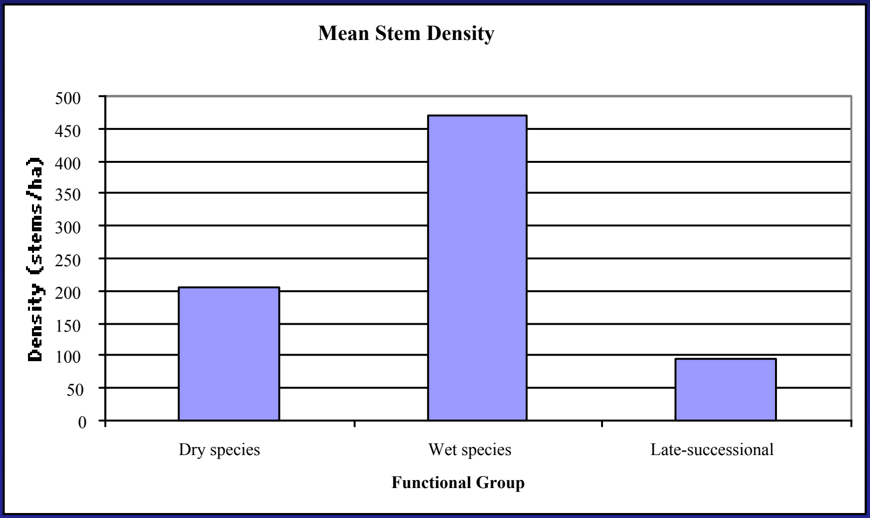
# Functional Groups

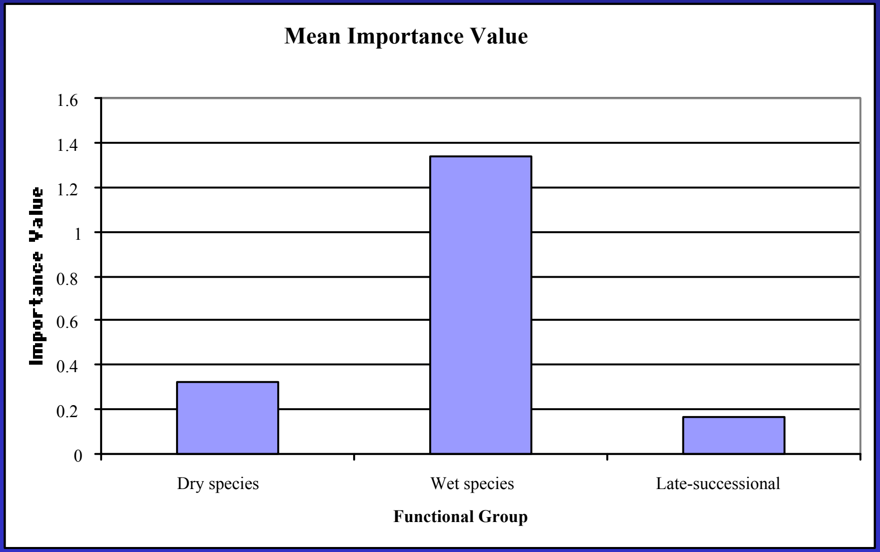
| Group | Species |
| --- | --- |
| Flood tolerant (wet) | *Acer saccharinum, Betula nigra, Fraxinus nigra, Fraxinus pennsylvanica, Populus deltoides, Quercus bicolor, Salix nigra, Ulmus americana* |
| Flood intolerant (dry) | *Quercus ellipsoidalis, Quercus velutina, Quercus rubra, Prunus serotina, Populus tremuloides* |
| Late successional | *Carya cordiformis, Carpinus caroliniana, Tilia americana* |

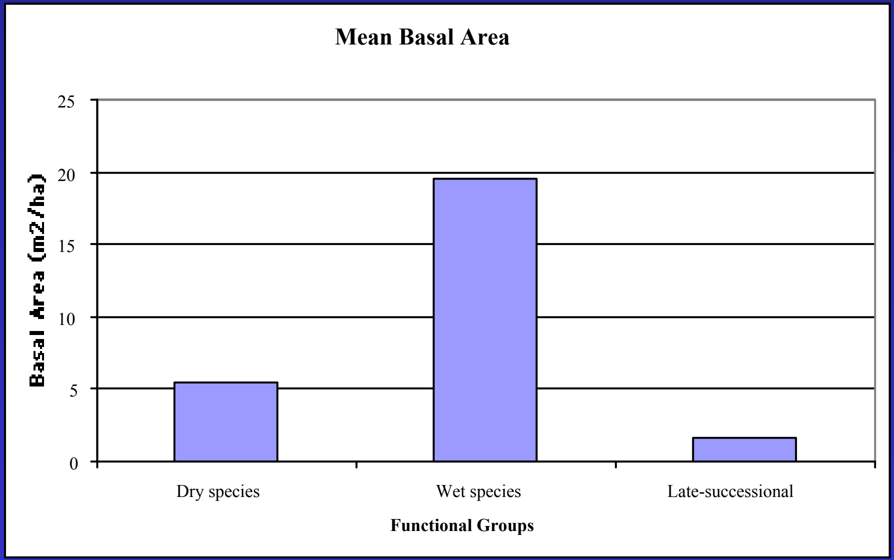
Mean abundance measures for functional groups (n=405)

Flood-tolerant species were dominant

Subsequent analyses reported for Importance value

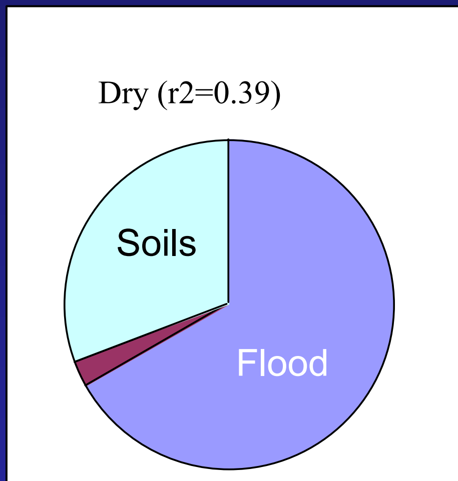


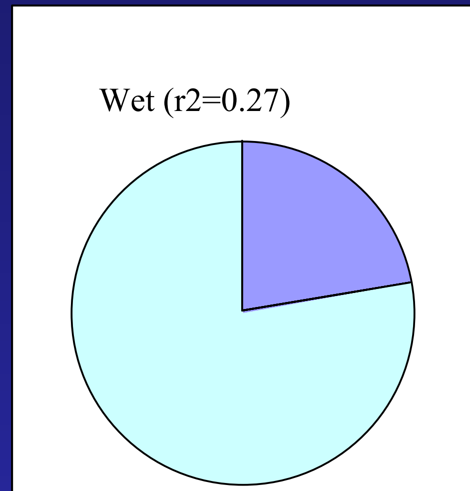



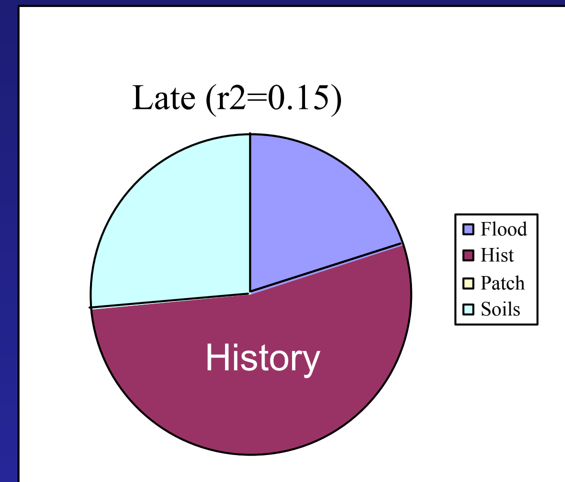



# Multiple Regression on Importance Values
## (relative contribution to explained variance)

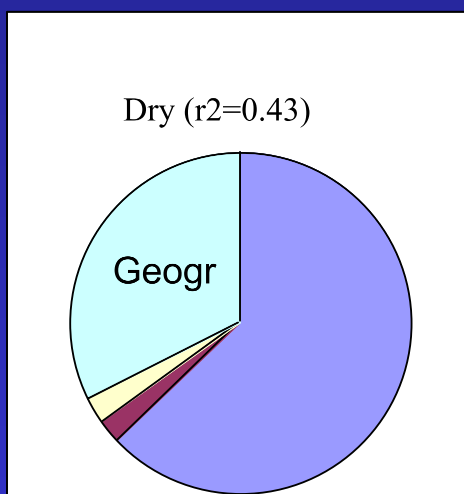
With soils

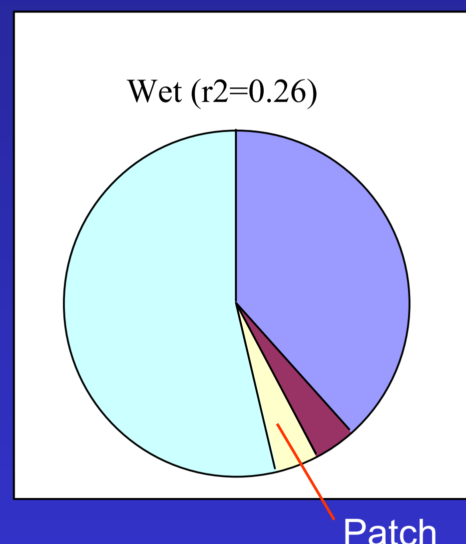


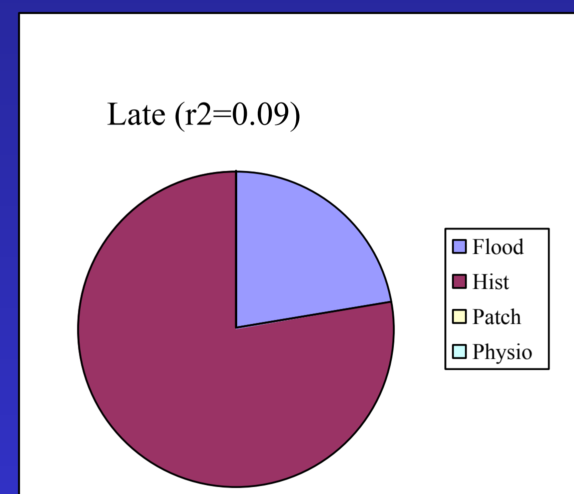




Without soils



# Functional Groups–Summary

- Flooding influence dominated by levee effect
- Land-cover history significant
- Dry species explained mostly by levee
  - Also soils or geographic province
- Wet species explained mostly by soil or geographic province
  - Also levee effect
- Late species explained by land-cover history

  Also levee effect

- Comparable models with and without soils
  - Landscape indicators generally worked well.

# Focal Species
(occurred on at least 10% of plots)

| **Species** | **Abbrev.** | **Common Name** |
|---|---|---|
| *Acer saccharinum* | AceSac | Silver maple |
| *Betula nigra* | BetNig | River birch |
| *Carya cordiformis* | CarCor | Yellowbud hickory |
| *Fraxinus pennsylvanica* | FraPen | Green ash |
| *Quercus bicolor* | QueBic | Swamp white oak |
| *Quercus velutina* | QueVel | Black oak |
| *Ulmus americana* | UlmAme | American elm |

# Models - Species Presence

Without soils

| Species | Geogr | Flooding | History | Patch | Concordance |
|---|---|---|---|---|---|
| AceSac | X | X | | X | 65% |
| BetNig | X | X | X | | 69% |
| FraPen | | X | X | | 66% |
| QueBic | X | | X | | 70% |
| UlmAme | X | | | | 65% |
| QueVel | X | X | X | X | 75% |
| CarCor | | X | X | | 69% |

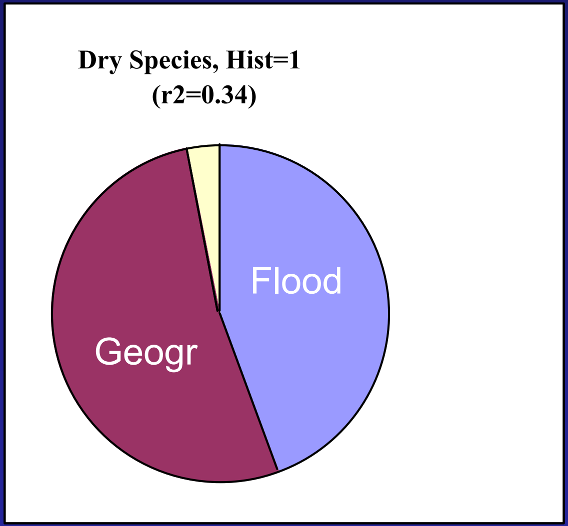
With soils

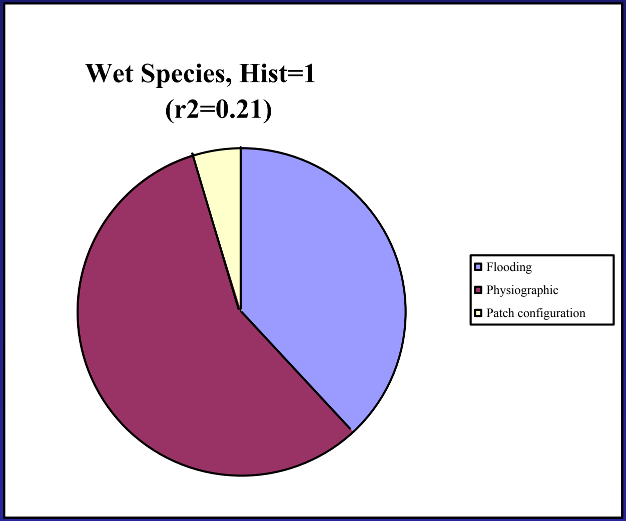
| Species | Geogr | Flooding | Hist | Patch | *Soils* | Concordance (% change) |
|---|---|---|---|---|---|---|
| AceSac | | | | | X | 70% (+5) |
| BetNig | | | | | X | 61% (-8) |
| FraPen | | X | X | | | 60% (-2) |
| QueBic | | X | X | | | 60% (+2) |
| UlmAme | X | | | | X | 66% (+1) |
| QueVel | X | X | X | X | X | 85% (+10) |
| CarCor | | | X | | X | 68% (+2) |

# Variation in Importance Value with Land-use History

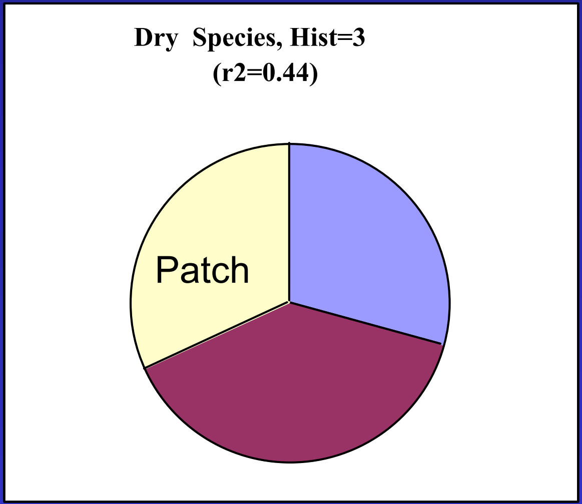
*Will patch configuration matter more in disturbed forest?*

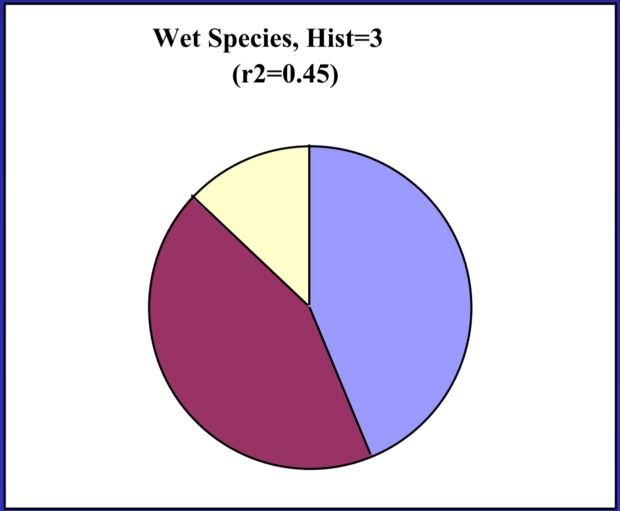
Forested before 1930s




Forested since 1960s



# Conclusions

- Abiotic template is important for floodplain trees, especially for flood-tolerant species

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- Abiotic template is important for floodplain trees, especially for flood-tolerant species
- Effects of human-induced changes must be considered to explain variation in the floodplain forest
  - Historic land cover
  - Modification of flow

# Key Tree Species

Floodplain Forest Birds

Coal Creek, Colorado

Baraboo River, Wisconsin

# Questions – Floodplain Birds

- To what extent do broad-scale measures account for variation in habitat occupancy by forest birds in a large-river floodplain?

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- To what extent do broad-scale measures account for variation in habitat occupancy by forest birds in a large-river floodplain?
- How much additional variation can be explained by local habitat measures?

Community

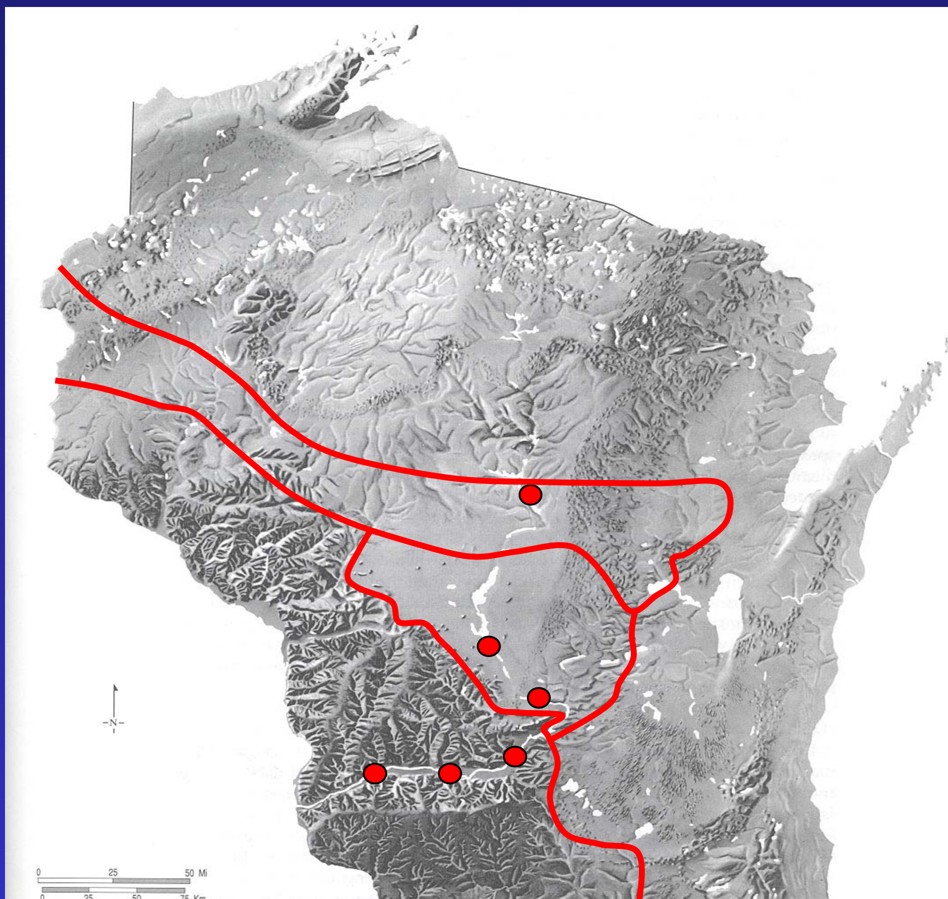
Guilds

Individual Species

Generality

Detail

# Geographic Measures




- River distance from the Mississippi River
- Northing
- Easting
- Geographic Province

# Landscape Measures

- patch area
- distance to patch edge
- distance to river
- floodplain forest width

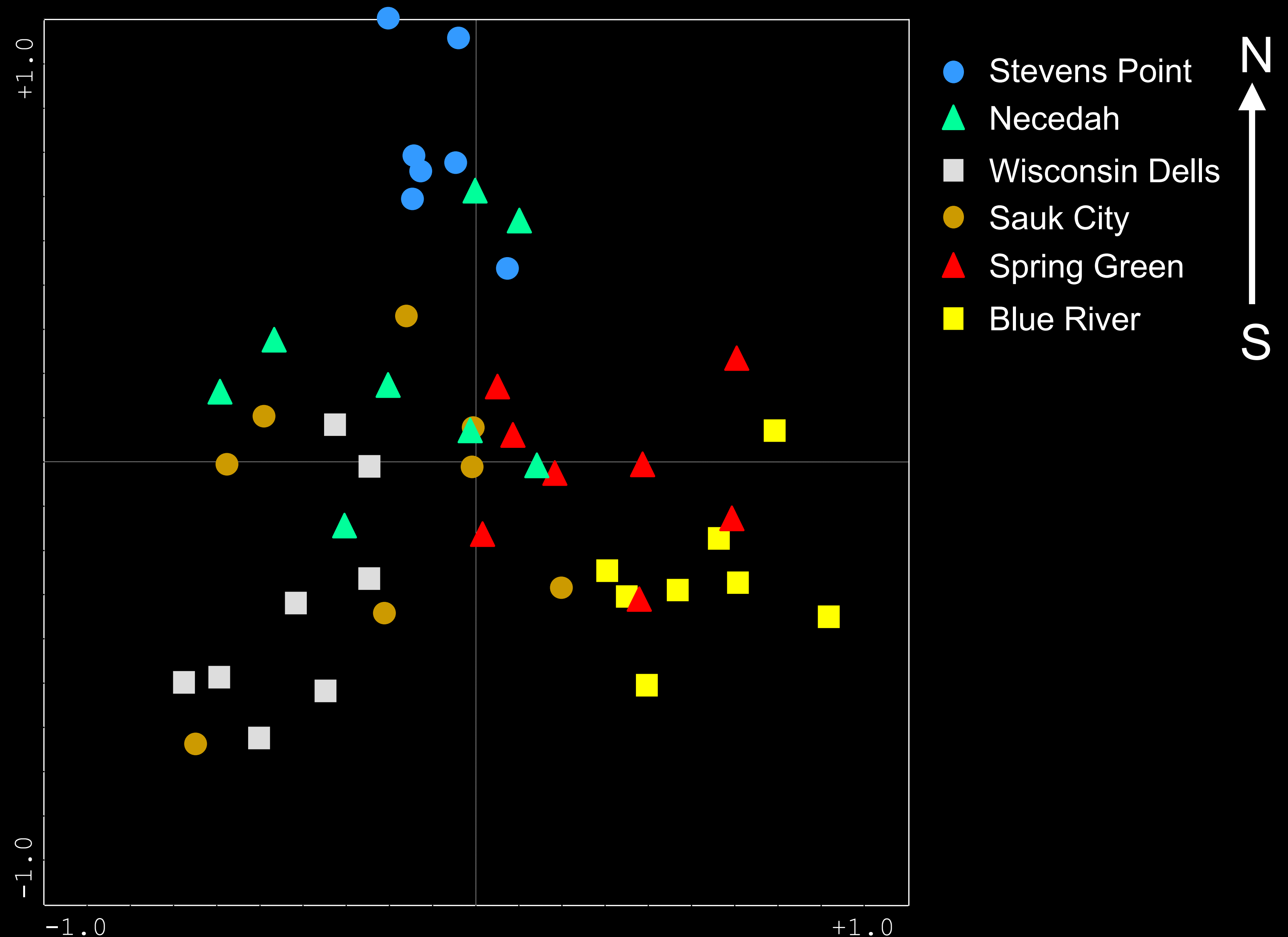
- forested area surrounding a transect within:
  - 100 m
  - 500 m
  - 1500 m
  - 3000 m

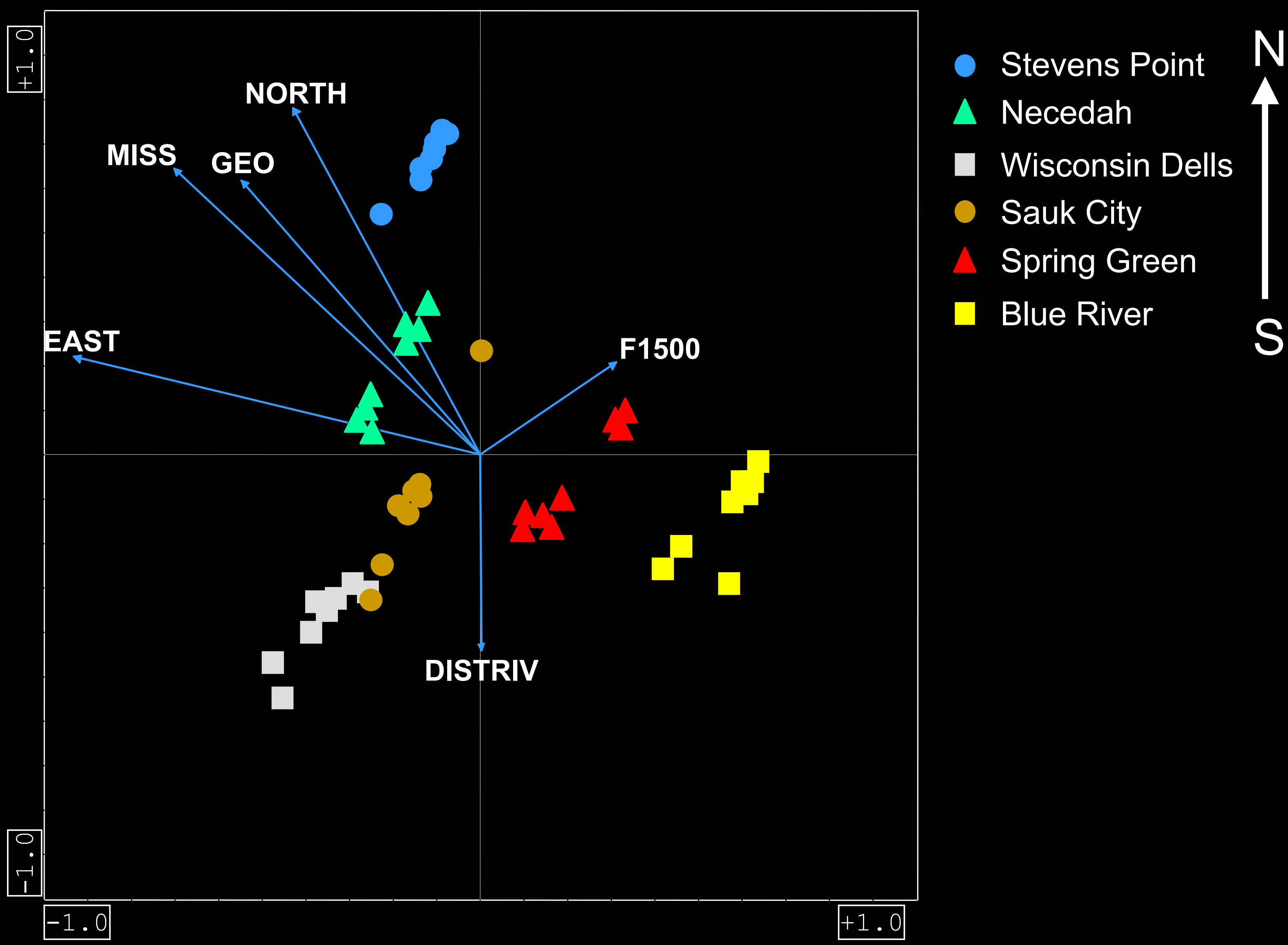
# Local Habitat Measures

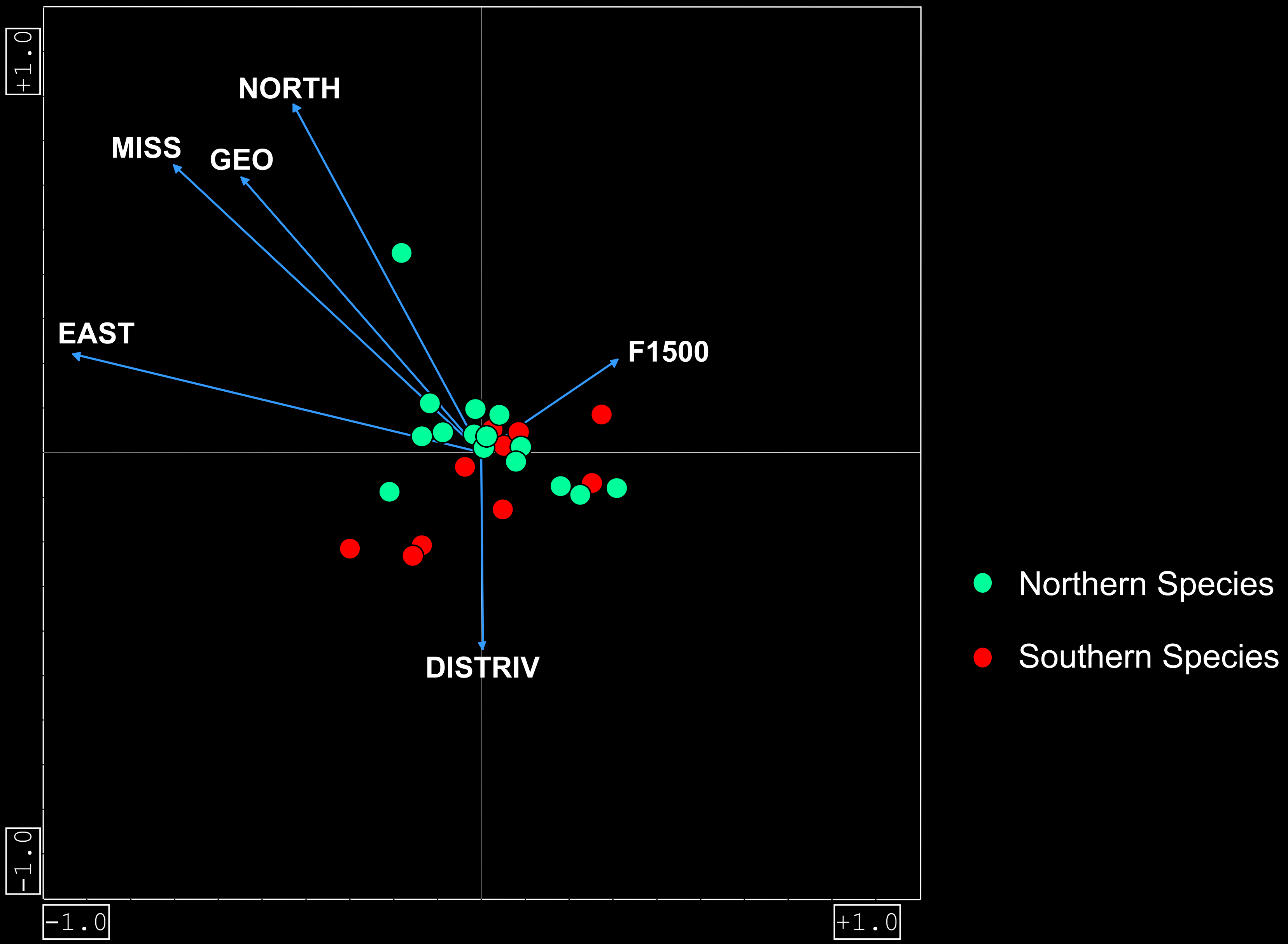
- canopy cover (3 layers)
- shrub cover
- herbaceous ground cover
- dominant tree species
- flood tolerance of dominant trees
- invasive shrubs
- number of lg. trees (>30cm dbh)
- number of standing dead trees
- canopy breaks
- land cover in 1930s and 1960s

# Bird Surveys

- point counts
- 6 reaches
- 8 transects per reach
- 5 points per transect
- points $\geq$120 m apart
- all birds seen and heard
- multiple observers
- 1999-2000
- 2x during the breeding season


+1.0
-1.0
-1.0
+1.0
Stevens Point
Necedah
Wisconsin Dells
Sauk City
Spring Green
Blue River
N
S


NORTH
MISS
GEO
EAST
F1500
DISTRIV
+1.0
-1.0
-1.0
+1.0
Stevens Point
Necedah
Wisconsin Dells
Sauk City
Spring Green
Blue River
N
S


NORTH
MISS
GEO
EAST
F1500
DISTRIV
+1.0
-1.0
-1.0
+1.0
Northern Species
Southern Species

Forest Interior Species
(n=9)

Forest Interior/Edge Species
(n=23)

Forest Edge Species
(n=20)

## Interior

| spp | Variables (partial $R^2$) | | | model $R^2$ |
|---|---|---|---|---|
| rich | -MISS (0.07) | F100 (0.05) | - | 0.13 |
| abun | - | - | - | - |

## Interior/Edge

| spp | | | | model $R^2$ |
|---|---|---|---|---|
| rich | -MISS (0.14) | -F1500 (0.09) | F100 (0.08) | 0.31 |
| abun | -MISS (0.11) | F100 (0.10) | -F1500 (0.04) | 0.25 |

## Edge

| spp | | | | model $R^2$ |
|---|---|---|---|---|
| rich | -MISS (0.21) | -F500 (0.14) | -DISTEDGE (0.04) | 0.39 |
| abun | -MISS (0.26) | -F500 (0.12) | -DISTEDGE (0.04) | 0.43 |

Neotropical Migrant Species
(n=26)

Short-Distance Migrant Species
(n=18)

Resident Species
(n=8)

| Neotropical Migrant spp | Variables (partial $R^2$) | | | model $R^2$ |
|---|---|---|---|---|
| rich | - | - | - | - |
| abun | - | - | - | - |

| Short Distance Migrant spp | | | | model $R^2$ |
|---|---|---|---|---|
| rich | -MISS (0.48) | -F500 (0.11) | - | 0.59 |
| abun | -MISS (0.43) | -F500 (0.06) | - | 0.49 |

| Resident spp | | | | model $R^2$ |
|---|---|---|---|---|
| rich | -MISS (0.32) | –DISTRIV (0.09) | - | 0.41 |
| abun | -MISS (0.18) | - | - | 0.18 |

# Woodpecker Species
(n=7)

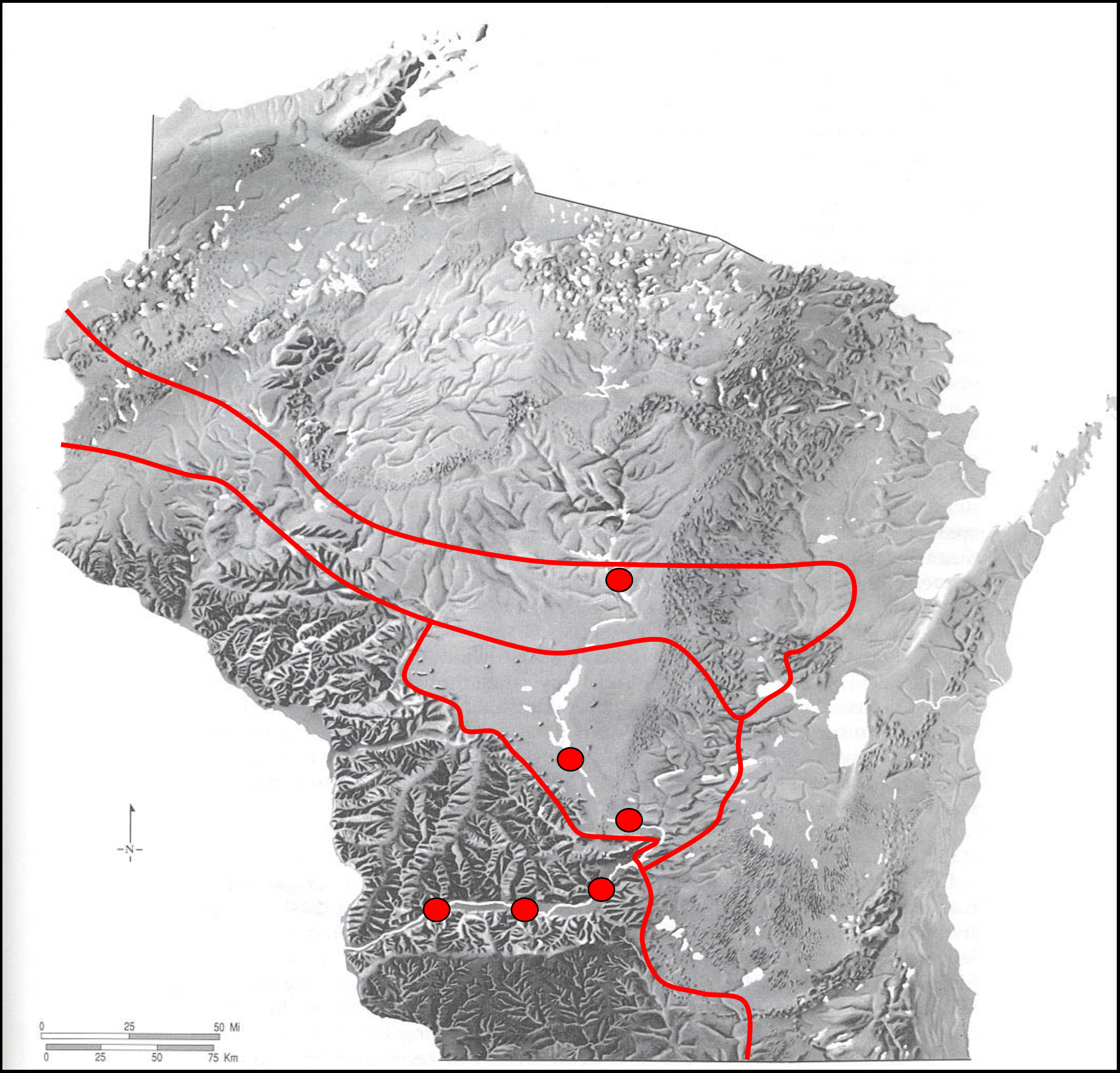
| Woodpecker spp | Variables (partial $R^2$) | | | model $R^2$ |
|---|---|---|---|---|
| rich | -MISS (0.42) | -DISTRIV (0.12) | -F1500 (0.04) | 0.58 |
| abun | -MISS (0.45) | -DISTRIV (0.08) | AREA (0.02) | 0.55 |

| spp | Local model $R^2$ | Landscape model $R^2$ |
|---|---|---|
| rich | 0.35 | 0.13 |
| abun | 0.34 | - |

| Interior/Edge spp | Local model $R^2$ | Landscape model $R^2$ |
|---|---|---|
| rich | 0.37 | 0.31 |
| abun | 0.47 | 0.25 |

# Conclusions

- Broad-scale measures explained a substantial portion of the variation in habitat use by some avian species in these floodplain forests.



N
0 25 50 Mi
0 25 50 75 Km

# Conclusions

- Broad-scale measures explained a substantial portion of the variation in habitat use by some avian species in these floodplain forests.

- For species commonly thought to be sensitive to habitat fragmentation, measures that have typically been used to quantify this process explained little of the variation in habitat use of floodplain forests along the Wisconsin River.

Habitat Edge

Wisconsin River